Installation and Operation Manual
X-DPT-Profibus-DP-Analog-Interface-eng
PN 541C062AAG
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Profibus - DP & Analog Interface for use with Brooks® Smart Mass Flow Meters Models 5860S, 5861S, 5863S, 5864S & Mass Flow Controllers Models 5850S, 5851S, 5853S

BROOKS® INSTRUMENT

Essential Instructions
Read before proceeding!

Brooks Instrument designs, manufactures and tests its products to meet many national and international standards. These products must be properly installed, operated and maintained to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, operating and maintaining Brooks Instrument products.

- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, please see back cover for local sales office contact information. Save this instruction manual for future reference.

⚠ WARNING: Do not operate this instrument in excess of the specifications listed in the Instruction and Operation Manual. Failure to heed this warning can result in serious personal injury and / or damage to the equipment.

- If you do not understand any of the instructions, contact your Brooks Instrument representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- Operation: (1) Slowly initiate flow into the system. Open process valves slowly to avoid flow surges. (2) Check for leaks around the flow meter inlet and outlet connections. If no leaks are present, bring the system up to the operating pressure.
- Please make sure that the process line pressure is removed prior to service. When replacement parts are required, ensure that qualified people use replacement parts specified by Brooks Instrument. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place to prevent electrical shock and personal injury, except when maintenance is being performed by qualified persons.

⚠ WARNING: For liquid flow devices, if the inlet and outlet valves adjacent to the devices are to be closed for any reason, the devices must be completely

European Pressure Equipment Directive (PED)

All pressure equipment with an internal pressure greater than 0.5 bar (g) and a size larger than 25mm or 1" (inch) falls under the Pressure Equipment Directive (PED).

- The Specifications Section of this manual contains instructions related to the PED directive.
- Meters described in this manual are in compliance with EN directive 97/23/EC.
- All Brooks Instrument Flowmeters fall under fluid group 1.
- Meters larger than 25mm or 1" (inch) are in compliance with PED category I, II or III.

European Electromagnetic Compatibility (EMC)

The Brooks Instrument (electric/electronic) equipment bearing the CE mark has been successfully tested to the regulations of the Electro Magnetic Compatibility (2004/108/EC (EMC directive 89/336/EEC)).

Special attention however is required when selecting the signal cable to be used with CE marked equipment.

Quality of the signal cable, cable glands and connectors:

Brooks Instrument supplies high quality cable(s) which meets the specifications for CE certification.

If you provide your own signal cable you should use a cable which is overall completely screened with a 100% shield.

"D" or "Circular" type connectors used should be shielded with a metal shield. If applicable, metal cable glands must be used providing cable screen clamping.

The cable screen should be connected to the metal shell or gland and shielded at both ends over 360 Degrees.

The shield should be terminated to an earth ground.

Card Edge Connectors are standard non-metallic. The cables used must be screened with 100% shield to comply with CE certification.

The shield should be terminated to an earth ground.

ESD (Electrostatic Discharge)

⚠ CAUTION: This instrument contains electronic components that are susceptible to damage by static electricity. Proper handling procedures must be observed during the removal, installation or other handling of internal circuit boards or devices.

Handling Procedure:

1. Power to unit must be removed.
2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.
3. Printed circuit cards must be transported in a conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.

Comments

This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs

Dear Customer,

We appreciate this opportunity to service your flow measurement and control requirements with a Brooks Instrument device. Every day, flow customers all over the world turn to Brooks Instrument for solutions to their gas and liquid low-flow applications. Brooks provides an array of flow measurement and control products for various industries from biopharmaceuticals, oil and gas, fuel cell research and chemicals, to medical devices, analytical instrumentation, semiconductor manufacturing, and more.

The Brooks product you have just received is of the highest quality available, offering superior performance, reliability and value to the user. It is designed with the ever changing process conditions, accuracy requirements and hostile process environments in mind to provide you with a lifetime of dependable service.

We recommend that you read this manual in its entirety. Should you require any additional information concerning Brooks products and services, please contact your local Brooks Sales and Service Office listed on the back cover of this manual or visit www.BrooksInstrument.com

Yours sincerely,

Brooks Instrument

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1 Introduction

1.1 HOW TO USE THIS MANUAL

This instruction manual is intended to provide the user with all the necessary information to operate and program the Brooks Instrument Smart Mass Flow Meters and Controllers on a Profibus-DP network. This manual should be used together with the *Installation and Operating Manual Smart TMF Series* (Brooks Instrument doc. #541-C-051), which covers the installation, operation and maintenance of Smart Mass Flow devices with respect to their intended use in a gas flow system.

This manual covers the additional device features as well as the installation and programming issues with respect to operating the Smart TMF Series devices on a Profibus-DP network.

This manual is organized in to five sections:

Section 1: Introduction

Section 2: Product Overview

Section 3: Installation

Section 4: Slave Configuration

Section 5: Diagnostic

Section 6: Model Listing

Appendix A: Profibus-DP Message Services

Appendix B: IEEE 754 Floating Point Format

It is recommended that this manual is read in its entirety, before connecting the device to the network and attempting to operate it over the network.

1.2 RELATED DOCUMENTS

The following documents are referred to in this document or are suggested for further reading:

1. *Installation and Operating Manual Smart Series TMF* - Brooks Instrument, doc. #541-C-051
2. *Installation and Operating Manual Smart-Control Software* - Brooks Instrument, doc. #541-C-054
3. *Installation and Operating Manual Smart DDE Software* - Brooks Instrument, doc. #541-C-057
4. EN 50170 (DIN 19245 Part 1) - *General Profibus standard* (PNO doc. #0.002)
5. EN 50170 (DIN 19245 Part 3) - *Profibus-DP standard* (PNO doc. #0.012)
6. *Implementierungshinweise zur DIN E 19245 Teil 3* (German, PNO doc. #2.041)
7. *Simatic-Net SPC3 Siemens PROFIBUS Controller - User Description, v1.5, 10/96,* Siemens AG 1996, document 6ES7-195-0BD00-8BA0.
8. *The rapid way to Profibus-DP*. M. Popp, 1997 (PNO doc. 4.072)

The PNO document numbers between brackets, refer to the PNO (German Profibus User Organization) documentation list.

1.3 DEFINITION OF TERMS

A.3.1 Terminology

GSD file	The GSD file contains the characteristic device data of the product, i.e. the device profile.
Input/Output	Profibus-DP conventions define all input/output directions as seen from the master system. Slave (sensor) data to be transferred to the master is referred to as **'input data'**. Data transferred by the master to the slave (e.g. com mands, setpoints) is referred to as **'output data'.**
Motherboard	Main electronics board of the Smart TMF series containing the main processor, sensor and valve interface and main connector.
Piggyback function memory.	Exchangeable board on top of and connected to the main board. This board provides the communications ality and holds the program and data
PNO	**P**rofibus **N**utzer **O**rganization. Profibus User Organization, based in Germany.
Profibus-FMS	**Pro**cess **fi**eld **bus** - **F**ieldbus **M**essage **S**pecification. Profibus protocol for high-level, object oriented data communication. Can be operated together with Profibus-DP.
Profibus-DP	**Pro**cess **fi**eld **bus** - **D**ecentralized **P**eriphery. Profibus protocol for high-speed, cyclic data communication.
Profibus-PA to	**Pro**cess **fi**eld **bus** - **P**rocess **A**utomation. Profibus proto col for intrinsically safe data communication, according IEC1158-2 and DIN E19245 T4.
SAP	**S**ervice **A**ccess **P**oint - Profibus definition for a communication service, e.g. SAP 62: Diagnostics message.
SPC3	Profibus-DP ASIC. Component manufactured by Siemens AG to provide Profibus-DP slave functionality to

A.3.2 Number Representations and Formats

Bit	Smallest binary information representation: 0 or 1
Nibble	Binary number representation, consists of 4 bits. Repre sents 1 value or 4 situations (‘bitmapped’). Usually nibbles appear grouped together in one or more bytes (i.e. two per byte). Examples: Value: binary 0011 = 3 decimal Bitmapped: binary 0111 = bits 0,1, and 2 are true, 3 is false
Byte or Octet	Binary number representation, consists of 8 bits. Repre sents 1 value or 8 situations (‘bitmapped’). Bits in a byte are numbered from right to left, i.e. least significant bit is bit 0, most significant bit is bit 7. Examples: Value: binary 00110011 = 51 decimal Bitmapped: binary 00010111 = bits 0,1,2 and 4 are true, others are false
Word	Combination of 2 bytes or 16 bits. Represents 1 value or 16 situations (‘bitmapped’). Examples: Value: binary 00010001 00110011 = 4404 decimal Bitmapped: binary 00010001 00010111 = bits 0,1,2,4,8 and 12 are true, others are false.
Decimal Examples:	Common numbers in the decimal number system. Range depends on size of the binary representation: 1 binary byte: range 0..255 decimal 2 binary bytes = 1 binary word: range 0..65535
Hexadecimal Examples:	Representation of numbers in the hexadecimal number system. Any written hexadecimal number in this manual is preceded by “0x” 0x25 = hexadecimal 25 = decimal 37 (1 byte) 0xB4 = hexadecimal B4 = decimal 180 (1 byte)
Real	Representation of fractional numbers according to IEEE-754 single precision floating point format definition. Size: 4 bytes Range: $\pm 3.4*10^{-38}$ to $\pm 3.4*10^{+38}$ Examples: 0x41 0x45 0x70 0xA4 = decimal 12.34

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2 Product overview

2.1 INTRODUCTION

This section is intended to provide the user with general product information on the Brooks Instrument Smart Mass Flow Meters and Controllers, equipped with the Profibus-DP interface. First a brief overview will be given of the standard features of the Smart TMF Series product family. For more in-depth information the reader is referred to the *Installation and Operating Manual Smart TMF Series* (Brooks Instrument, doc. #541-C-051). In addition to this, an overview of the Profibus-DP specific product features of the Smart TMF Series equipped with the Profibus-DP interface will be given.

2.2 THE BROOKS SMART MASS FLOW PRODUCTS

The Brooks Smart Mass Flow Meters, Models 5860S, 5861S, 5863S and 5864S measure gas flow accurately. The heart of the system, is the thermal mass flow sensor which produces an electrical output signal as a function of flow rate.
In addition the Brooks Smart Mass Flow Controllers, Models 5850S, 5851S and 5853S are equipped with an electromechanical valve, allowing them to control gas flows. The flow ranges per model are listed in Table 2-1 below.

Table 2-1: Brooks Smart Mass Flow Meters and Controllers.

Brooks Smart Mass Flow Products				
Mass Flow Controller Model	Mass Flow Meter Model	Flow Ranges		
		Min. full scale	Min. full scale	Unit*
5850S	5860S	0.003	30	l_n/min
5851S	5861S	20	100	l_n/min
5853S	5863S	100	1000	l_n/min
	5864S	18	2160	m_n^3/hr

* The index n refers to ‘normal’ conditions, i.e. 0°C, 1013.25 mbar.

Standard features of the Brooks Smart series include:

- High accuracy and repeatability.
- Selectable analogue setpoint input/flow rate output signals.
- Adaptive signal filtering.
- Fast response to setpoint changes.
- Programmable softstart ramp rate.
- Powerful adaptive control to provide optimal control behaviour and response under varying process conditions.
- Programmable valve override function.
- Programmable totalizer function.
- High-Low flow alarms.
- Continuous self diagnostics to ensure system integrity as well as signal diagnostics to ensure process integrity.
- Programmable alarm signalling options.
- Selectable communication protocol options.

The electronics as used on all models consist of two printed circuit boards:
1. a motherboard, containing the main processor, the calibration database, the sensor and signal I/O, valve drive, power supply conditioning and the main 15-pin sub-D connector, and
2. a piggyback board on top of the motherboard containing the program memory and optional digital communication hardware.

The standard piggyback board (part number 097-B-225-ZZZ) contains all the necessary hardware and software to implement the standard HART based digital communication protocol, providing access to all calibration data as well as actual data, diagnostics and alarms. The hardware allows the protocol to be operated on either RS-232 or RS-485 (dip switch selectable) and on a number of baud rates (1200 baud up to 38400 baud). Windows based software is available to facilitate communication with a PC (Refer to *Installation and Operating Manual Smart-Control software* - doc. #541-C-054 and *Installation and Operating Manual Smart DDE software*, doc. #541-C-057 for more information).

A second type of piggyback board (part number 097-B-296-ZZZ) is now available containing all the necessary hardware and software to implement the Profibus-DP digital communication protocol, providing access to a (limited) number of settings, the actual data, diagnostics information and alarms. The Profibus-DP implementation, as defined in the Profibus standard EN 50170, allows the Smart TMF series to be connected to an RS-485 network and to be operated from a master device (e.g. a PLC) using the Profibus-DP protocol at communication speeds of up to 12 Mbaud.

Both piggyback boards are interchangeable, and provide the same control, analogue I/O, diagnostics, and alarm functions as well as accuracy and performance. Also since the database is located on the motherboard the calibration will not be affected by changing the piggyback board. The next section will discus the Profibus-DP features and function in more detail.

2.3 PROFIBUS ON THE SMART TMF SERIES

The Profibus piggyback board on the Brooks Smart TMF series is provided with all the necessary hardware and software to implement Profibus-DP functionality on an RS-485 network according to the EN 50170 Profibus standard. The Profibus piggyback board is equipped with an additional 9-pin sub-D connector, as defined by EN 50170, to allow easy connection to the network, separate from the main connector. The main 15-pin sub-D connector is still needed for the power supply, but also allows for the standard analogue I/O signals, analogue valve override and (open-collector) alarm signalling to be used separately from the network connection.
Communication can be performed at a number of baud rates ranging from 9600 baud up to 12 Mbaud. The communication electronics allows for automatic baud rate detection, thus making the need for any hardware baud rate selection methods not required. For selecting the device address, which must be unique on the network, two rotary switches are provided. This allows a user to easily select any address number ranging from 0 to 99, also providing the possibility for fast device replacement, without the need for complex network configuration.

The PROFIBUS-DP communication option supports the following message types:
- Cyclic data exchange (Write/Read data).
- Read inputs (e.g. status, flow, temperature, totalizer, etc.).
- Read outputs (e.g. commands, setpoint).
- Global control commands (e.g. fail safe, sync).
- Get configuration (i.e. read number of I/O bytes and composition).
- Read diagnostics information (i.e. get error and alarm status).

- Set parameters (i.e. select gas number, engineering units, I/O configuration etc.).
- Check configuration (i.e. check I/O composition).

These message types provides the user with the possibility to select a number of operational settings, as well as to define which actual data are to be exchanged in the data exchange mode. This allows for the selection of only a minimum of (required) data to be exchanged, thus conserving memory at the master or for the selection of all the actual data. Diagnostics information can be obtained when needed, providing information on device and process integrity as well as communication integrity.
Additional features not available on the standard communication protocol include fail safe option (i.e. pre-programmed device behaviour in case of a network failure) and sync/unsync, allowing for synchronized behaviour for a group of devices.

Calibration data as well as device data are not available through the Profibus-DP communication, but will require a standard communication piggyback board. Also Profibus-DP/V1 (extended Profibus-DP implementing a-cyclic data transfer), or Profibus-FMS functionality are not implemented, although they can be operated on the same network. Profibus-PA functionality, providing data transfer on intrinsically safe networks is also not supported.

Finally the Profibus-DP piggyback board is equipped with a zero command pushbutton, allowing the user to give a manual command to the device to (re)balance the flow sensor electronics. This command can also be issued through the protocol.

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3 Installation

3.1 INSTALLATION

This section discusses the installation requirements for the Smart Mass Flow Meter/Controller models equipped with the Profibus-DP interface. It will focus only on the installation requirements necessary to operate the device on a Profibus network as well as on other issues, related to this interface. The reader is referred to the *Installation and Operating Manual Smart TMF series* (Brooks Instrument, doc. #541-C-051) for general installation and operating instructions of the device in the gas flow measurement/control application as well as for further information on standard electrical interfacing.

3.2 ELECTRICAL INTERFACING

3.2.1 General

All Brooks Smart TMF devices are equipped with a male 15-pin sub-D connector, providing all the necessary connections to operate the device at least in an analogue way. This allows the device to be used as a simple plug-in replacement for earlier analogue mass flow meter/controller models, offering the improved performance and additional features of the digital implementation. Two pins on this connector, pin 14 and 15, are reserved for the connection of a digital
communications protocol. Whether these pins are used for this purpose, will depend on the type of piggyback board installed. The standard piggyback board will offer HART based communication over either RS-232 or RS-485 through these pins. If these pins are not used, the installed piggyback will have to provide a separate interface (connector) to allow connection to the network.

In the case of the Profibus-DP interface for the Brooks Smart Mass Flow Meter/ Controller models, pin 14 and 15 on the main connector are not used. The installed piggyback board will provide a separate connector for network connections. This connector is a female 9-pin sub-D connector, specified by the Profibus standard as the preferred connector (refer to EN 50170, part 1). Pin layout on this connector is according to this standard.

NOTE: The presence of this separate connector does NOT make the main connector redundant. The main connector must at least be used to provide the necessary power to the device. In addition however, all the other, non-communication related functions are still available through this main connector.

3.2.2 Main connector

The male 15-pin sub-D connector provides all necessary functionality to operate the device. Despite the presence of a Profibus network connection, all the pins, except for pin 14 and pin 15, retain their functionality and they can still be used. For some pins the functionality is selectable (ON/OFF), whereas other pins can be used in parallel to the network connection. This allows the device to be used as a plug-in replacement for an analogue mass flow meter or controller with the Profibus-DP communication in a monitoring role. It can however also be used as a Smart Mass flow meter/controller, fully driven through the network connection. Also a mix of both is possible. Figure 3-1 shows the pin layout and numbering of the main connector. Table 3-1 lists the pin-configuration of the main 15-pin sub-D connector.

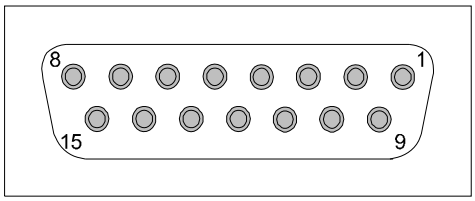

Figure 3-1: Smart TMF Main 15-Pin Male Sub-D Connector - Pin Numbering.

Table 3-1: Smart TMF Main Connector Pin Layout.

Pin number	Function	
	Models 5850S, 5851S, and 5853S	Models 5860S, 5861S, 5863S and 5864S
1	Setpoint return (-)	Not used
2	0(1) - 5 Vdc Flow signal output	0(1) - 5 Vdc Flow signal output
3	(TTL) Open collector alarm output	(TTL) Open collector alarm output
4	0(4) - 20 mA Flow signal output	0(4) - 20 mA Flow signal output
5	+15 Vdc to +28Vdc Power supply	+15 Vdc to +28Vdc Power supply
6	-15 Vdc Power supply if required	Not used
7	0(4) - 20 mA Setpoint input	Not used
8	0(1) - 5 Vdc Setpoint input	Not used
9	Power supply common	Power supply common
10	Flow signal output common	Flow signal output common
11	+5Vdc reference output	Not used
12	Valve override input	Not used
13	Not connected	Not connected
14	RS-232 RxD/RS-485 A- **	RS-232 RxD/RS-485 A- **
15	RS-232 TxD/RS-485 A+ **	RS-232 TxD/RS-485 A+ **

* Not connected indicates “not electrically connected internally”. Not used indicates “electri cally connected internally, but serves no purpose”.

** Pin 14 and 15 are connected through to the piggyback board and are reserved for the digital communication option in case the standard piggyback is installed. In case the Profibus-DP piggyback is installed, these pins are not connected.

The minimum requirement to operate the device on a Profibus network is the connection of the power supply lines, pin 5 (+15 Vdc to +28Vdc) and pin 9 (power supply common). For some Mass Flow Controller models, operating on +15 Vdc and -15 Vdc, providing the -15 Vdc power supply on pin 6 is also required (refer to the *Installation and Operating Manual Smart TMF series*, doc. #541-C-051).

The analogue output signals, representing a measure for the flow on pin 2 (voltage output), pin 4 (current output) and pin 10 (flow signal output common) can be used in parallel with the network. Information on the flow can be obtained through the network (in engineering units), but at the same time as a voltage or current level through pin 2, 4 and 10. However, these pins can also be set to OFF through the network, forcing them to the 0 volt/current level.

The setpoint command (Smart Mass Flow Controller models only), can be issued either through the Profibus network or through an analogue signal level.

The user has to define the setpoint source and (in the case of an analogue signal input) the setpoint level through the network. If the setpoint command is to be issued through an analogue level on pin 7 (current input) or pin 8 (voltage input) and pin 1 (setpoint return signal), it can be monitored over the Profibus network at the same time. If the setpoint command is issued over the Profibus network, any analogue setpoint signal on pin 7 or 8 is ignored.

The valve override input signal on pin 12 (Smart Mass Flow Controller models only) can always be used in parallel to the network. The command issued through pin 12 (OPEN or CLOSE) always takes precedence over the network valve override command. If the level on pin 12 is left floating (not connected) a valve override command issued through the network connection will be carried out.

The TTL open collector alarm output (pin 3) can always be used in parallel with the network. Any (enabled) system diagnostics signalling will activate the alarm output and simultaneously result in a diagnostics message through the network.

3.2.3 Additional Profibus connector

The Profibus-DP piggyback board is equipped with a separate female 9-pin sub-D connector. The connector type as well as the pin layout is compatible with the preferred connector as stated in the Profibus standard EN 50170. This allows for the use of standard available, Profibus approved network connectors, enabling fast and easy connection to a Profibus network. The connector will be located on the side of the device. Figure 3-2 below shows the pin numbering on the female 9-pin sub-D Profibus connector. The connector is located on the side of the Smart Mass Flow device. Table 3-2 below lists the pin-configuration of the Profibus-DP connector on the Smart TMF Series as well as the signal definition according to the standard EN 50170.

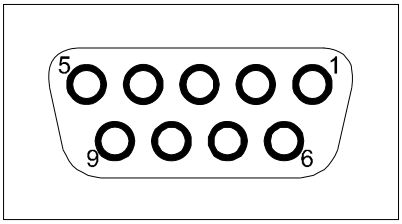

Figure 3-2: Profibus 9-Pin Female Sub-D Connector - Pin Numbering.

The connector provides the four mandatory signals as defined in EN 50170, i.e. RxD/TxD-P, RxD/TxD-N, VP and DGND. The other defined signals, the 24 Vdc power supply option as well as the optional repeater control signals, are not supported and therefore not connected on the Smart TMF Series Profibus piggyback board.

Pin 1 is defined as the shield connection. In the Smart TMF series devices the shield is not connected to this separate pin. Instead shield connection must be provided to the housing, through the connector shield.
The supported signals are buffered, but not galvanically isolated. Also the required line termination is not provided within the Smart TMF Series device itself. Refer to Section 3.4 for network wiring instructions.

Table 3-2: Smart TMF Profibus-DP Network Connector Pin Layout.

Pin number	Signal	Function	
		Smart TMF series Profibus-DP connector	EN 50170 standard definition
1	Shield	Not connected	Shield/protective ground
2	M24	Not connected	Ground of 24 Vdc powersupply
3	**RxD/TxD-P**	**RxD/TxD - A+**	**RxD/TxD - A+**
4	CNTR-P	Not connected	Control signal for repeaters (direction control)
5	**DGND**	**Digital ground for terminating resistance**	**Digital ground for terminating resistance**
6	**VP**	**Digital +5 Vdc supply for terminating resistance**	**Digital +5 Vdc supply for terminating resistance**
7	P24	Not connected	24 Vdc power supply
8	**RxD/TxD-N**	**RxD/TxD - A-**	**RxD/TxD - A-**
9	CNTR-N	Not connected	Control signal for repeaters (direction control)

Signals in bold type face are mandatory according to EN 50170.
Signal names are according to EN 50170.

3.3 SUPPORTED BAUD RATES

Since the Profibus-DP interface has been implemented using the Siemens SPC3 Profibus-DP slave ASIC, the baud rates supported are determined by the capabilities of this component. The baud rates supported are listed in Table 3-3 below (Refer to doc. 6ES7-195-0BD00-8BA0: *Simatic-Net SPC3 Siemens PROFIBUS Controller - User Description, v1.5, 10/96,* page 19, Siemens AG 1996).

The SPC3 also supports automatic baud rate detection. Therefore no hardware means are necessary to select the required baud rate at the slave. Communication initiated by the master at a any of the supported baud rate values will cause the Brooks Smart TMF series device to lock on to this baud rate after an automatic search for it. Also, if no valid messages have been detected on the network after a pre-programmed time out, the Brooks Smart TMF series will switch to baud search mode, and search for the correct baud rate until found.

Table 3-3: Supported Baud Rate Values.

Baud rate	Max. response time	Max. cable segment length
12 Mbaud	67 µsec (800 Tbit*)	100m/327 feet
6 Mbaud	75 µsec (450 Tbit*)	100m/327 feet
3 Mbaud	83 µsec (250 Tbit*)	100m/327 feet
1.5 Mbaud	100 µsec (150 Tbit*)	200m/655 feet
500 kBaud	200 µsec (100 Tbit*)	400m/1311 feet
187.5 kBaud	320 µsec (60 Tbit*)	1000m/3278 feet
93.75 kBaud	640 µsec (60 Tbit*)	1200m/3934 feet
45.45 kBaud**	8.8 msec (400 Tbit*)	1200m/3934 feet
19.2 kBaud	3.125 msec (60 Tbit*)	1200m/3934 feet
9600 Baud	6.25 msec (60 Tbit*)	1200m/3934 feet

* Tbit is the time required to send 1 data bit, at the associated bit rate. Refer to standard EN 50170.

** 45.45 kBaud is only used for Profibus-DP and Profibus-PA systems with coupling devices.

3.4 PROFIBUS NETWORK WIRING

3.4.1 Profibus Network Wiring Requirements

The physical network connection with Brooks Smart TMF devices to be used with Profibus-DP communication is based on RS-485. The standard EN 50170 specifies the type of cable to be used for this implementation. Table 3-4 below lists the required cable parameters as specified by EN 50170.

The Profibus cable is a shielded twisted pair cable. The shielding must be connected to protective ground (i.e. conductive housing on Brooks Smart TMF series devices) in order to prevent EMC interference from entering the device.

Table 3-4: Profibus Cable Parameters.

Parameter	Line type A	Unit
Impedance	135 to 165	[Ω]
Capacitance per unit length	< 30	[pF/m]
Loop resistance	110	[Ω/km]
Core diameter	0.64	[mm]
Core cross section	> 0.34	[mm^2]

3.4.2 Line Termination Requirements

Line termination on RS-485 is defined by EN 50170 and should be provided at the start and at the end of each network cable segment. Figure 3-3 below shows the line termination configuration at the start/end of a network cable segment.

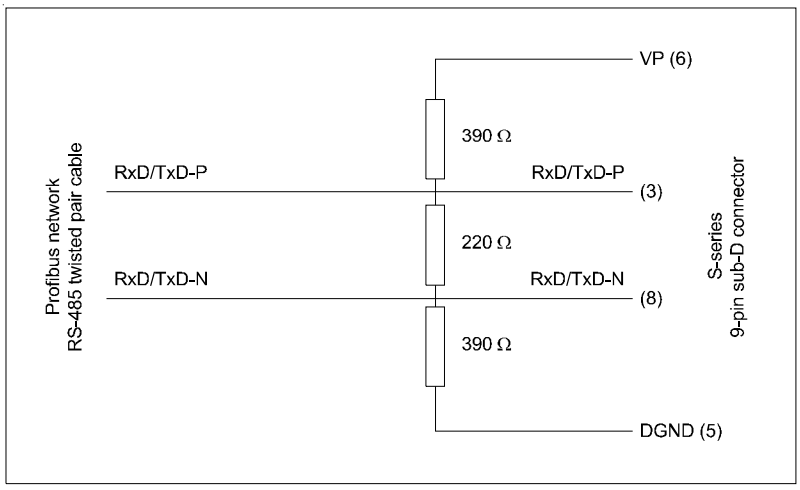

Figure 3-3: Profibus Line Termination Configuration.

The Brooks Smart TMF series does not provide internal termination resistors. Therefore, if required at the connector of a Smart TMF series device (e.g. because it is at the end of a network cable segment) the termination resistors have to be provided through the mating connector on the network cable.

Special Profibus connectors, with build-in line termination resistors, which can be switched on or off, are available from a number of vendors (e.g. Siemens, Erni Components etc.). These connectors usually provide internal screw terminals for cable connection and their pin layout is according to the definition given in EN 50170. Also convenient means are usually provided to connect the cable shield to the protective ground. Refer to the Profibus Organization for more information on availability of these connectors.

3.4.3 Special Requirements for High-Speed Communication

In case the network is to be operated at baud rates higher then 1.5 Mbaud, the cable length in combination with the capacitive load of the station may generated line reflections, causing interference. This may make communication at these baud rates impossible.

In order to prevent these effects special precautions must be taken.
A special connection plug combination is required, including two serially placed inductors each one in each network line. It is recommended that the inductors be placed in the connector rather than in the Profibus device. It is also recommended to place inductors in each line segment starting or ending at any station connector. There fore stub lines should also not be used, when operating the network at high baud rates.
The value of each inductor is determined to be 120 nH, assuming the total capacity for a bus station of approximately 30pF (taking in to account the capacity of the connector, the line length to the RS-485 driver etc.). Refer to Figure 3-4 below for installation. The before mentioned special Profibus connectors often include the inductors for each cable segment connected to that connector. Ensure that the selected connector is suited for operation at higher baud rates then 1.5 Mbaud.

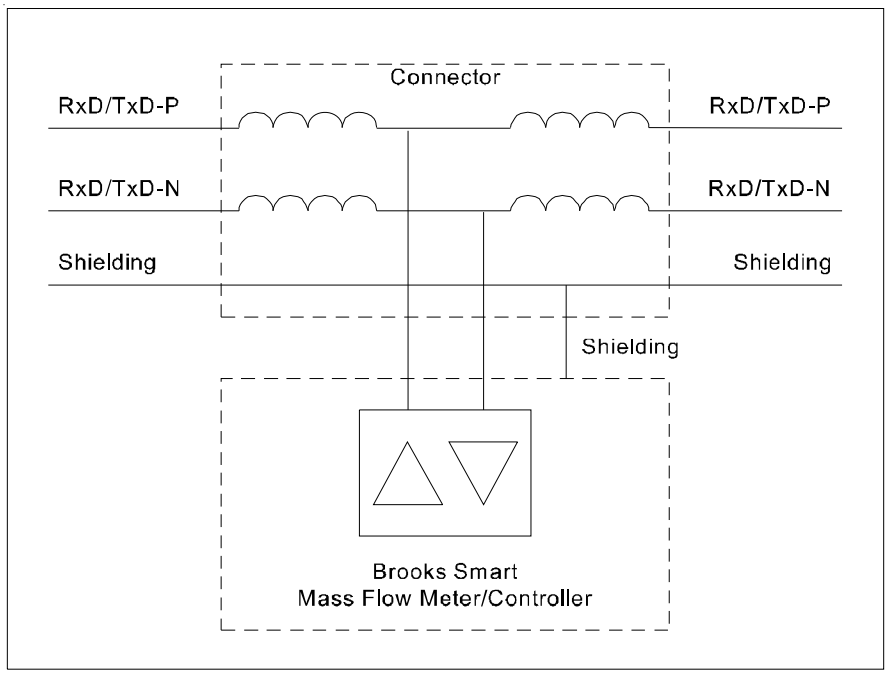

Figure 3-4: High-Speed Communication Inductors.

3.5 STATION ADDRESS SELECTION

In order for a Profibus network master device to be able to address individual slave devices on the network, a slave device will require the assignment of a unique communication address or station address. This must be done prior to being connected to the network. The slave address can be 126 at maximum since 127 is the Global Station Address.
On the Profibus interface piggyback for the Broos Smart TMF devices, the station address selection is implemented by two rotary switches, located on the side of the device (location of the valve), refer to Figure 3-5 below. Each of the switches allow a setting of an integer number, the units between 0 and 9 and the decimals 0 and 12. The decimal address digit indicates the multiples of ten, whereas the unit address digit indicates the multiples of one. Therefore the allowable station address number ranges from 0 to 126.
The decimal switch has a labelling from 0 through F, which is hexadecimal. The letters A through F respresents 10 through 15. The letter D, E and F are not allowed since they represent addresses in the range 130, 140 and 150, which is outside the Profibus range of 126. If the total address selection is 126 or higher, the slave address is 126.

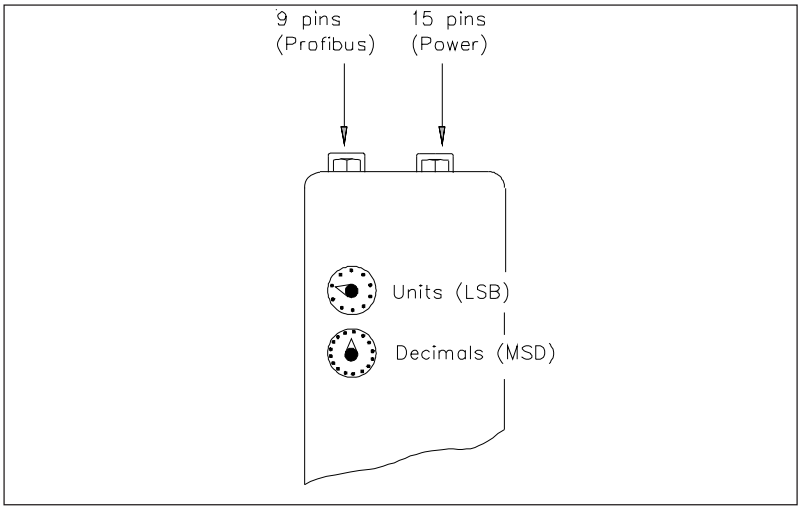

Figure 3-5: Smart Mass Flow Meter/Controller - Outlet View.

The Profibus-DP standard EN 50170 also defines the option of setting the station address through communication. This option has been disabled in the Brooks Smart TMF series Profibus interface and the associated communication service (SAP 55) can not be used. Refer to section Appendix A for more information on supported communication services.

On top of this unique address number each slave uses three other address numbers:

1. **Identity number**: This number is a unique, fixed, WORD size number assigned by the Profibus Organization PNO to each type or class of devices. It is programmed in the device's source code and it is used to establishes the link between the class of devices and its associated GSD file (refer to section Appendix B). It is by standard definition part of the addressing mechanism and as such part of every communication service.
2. **Global station address**: This station address, number 127, is a Profibus defined address to be used in the transmission of global control command messages. All slave devices connected to a network will recognize this number as a valid address. Whether they will act up on this command when received will depend on the third addressing option, which must be used together with this global station address.
3. **Group number**: An additional address number can be assigned by the user to a group of (different) devices. This group number, one byte in size must be set as part of the parameterization service. It can be used in the global command service next to the global station address, to send command to a (sub) group of devices on a network. Refer to section Appendix A for more information.

3.6 ZERO PUSHBUTTON

In order to be able to initiate a sensor zero request to (re)balance the flow sensor, the device is equipped with a pushbutton. Pressing this button will cause the processor to perform the necessary action to accomplish this. The action can also be initiated through the protocol, by setting the appropriate bit flag in the first command byte. Refer to section A.4 for more information on how to accomplish the zero command through the protocol.

The zero pushbutton is located on the opposite side of the Profibus-DP address selector switches on the Brooks Smart TMF device. To achieve a valid (re)-balance of the flow sensor, take the following actions:

1. Make sure the device has been fully warmed up after power-up, i.e. it should be powered up for at least 45 minutes.
2. Make sure that now gas flow through the device is present. If there has been any gas flow through the device after power-up, leave the device without gas flow for 15 minutes, in order to stabilize the sensor.
3. Press the zero pushbutton and wait for 10 seconds. After that, the (re)balancing of the sensor has been completed and the device is ready to be used. Now gas flow can be (re)applied to the device

4 Slave Configuration

4.1 INTRODUCTION

For the Profibus-DP network configuration of the Smart Mass Flow Controllers / Meters slaves GSD files are provided. These files are:
1. BIMF5800.GSD - Smart Mass Flow Controllers
2. BIMF5860.GSD - Smart Mass Flow Meters

The user can make the selections as listed in the next section using a configurator program and the files provided. The Brooks Smart Mass Flow Controller and Meter are classified as a compact device.
Using the configurator and with the selected device, “S-series MFC”, the parameters can be viewed and adjusted against the customer configuration of the device. The GSD file supports two modules, “Basic” and “Extended”. The input bytes are identical for both modules, the difference is in the output bytes. In the “Extended” module a ‘command’ byte is included. See also 4.3, Memory Map.

An overview of these parameters is given in the next section.

4.2 PARAMETER SELECTIONS

4.2.1	Model: CONTROLLER / METER
Gas number selection (Select one of the ten possible calibration curves. In case of more than one calibration curve (different gasses) this is listed on the order.)	1. curve 1 2. curve 2 3. curve 3 4. curve 4 5. curve 5 6. curve 6 7. curve 7 8. curve 8 9. curve 9 10. curve 10 *(default = 1)*

4.2.2	Model: CONTROLLER / METER
Analogue Output selection (Selection of the analogue output signals.)	1. Off. 2. 0-5 Vdc/0-20 mA 3. 1-5 Vdc/4-20 mA *(default = 2)*

4.2.3	Model: CONTROLLER / METER
1.Flow Sensor Error	Enable / Disable
2.Temperature Sensor Error	Enable / Disable
3.Analogue Output Error	Enable / Disable
4.Setpoint Overrange	Enable / Disable *
5.Flow Sensor Out Of Range	Enable / Disable
6.Output Out Of Range	Enable / Disable
7.Valve Out Of Range	Enable / Disable *
8.Low Flow Alarm	Enable / Disable
9.High Flow Alarm	Enable / Disable
10.Totalizer Overflow	Enable / Disable
11.Temperature Too High	Enable / Disable
12.Power Supply Too Low	Enable / Disable
13.No Flow Indication	Enable / Disable *
14.Temperature Too Low	Enable / Disable
15.Flow Obstruction	Enable / Disable *
	(default = all Enabled)
(Enable or disable the generation of alarms from the Mass Flow slave.)	(* = not for meters)

4.2.4	Model: CONTROLLER / METER	
Flow Unit selection (Selection of the used flow unit in which both the Setpoint and Flow values are expressed.)	1. %	Percent of full scale.
	2. ml/sec	Milliliter per second.
	3. ml/min	Milliliter per minute.
	4. ml/hr	Milliliter per hour.
	5. l/sec	Liter per second.
	6. l/min	Liter per minute.
	7. l/hr	Liter per hour.
	8. m3/sec	Cubic meter per second.
	9. m3/min	Cubic meter per minute.
	10. m3/hr	Cubic meter per hour.
	11. ft3/sec	Cubic feet per second.
	12. ft3/min	Cubic feet per minute.
	13. ft3/hr	Cubic feet per hour.
	14. g/sec	Grams per second.
	15. g/min	Grams per minute.
	16. g/hr	Grams per hour.
	17. kg/sec	Kilograms per second.
	18. kg/min	Kilograms per minute.
	19. kg/hr	Kilograms per hour.
	20. Lb/sec	Pounds per second.
	21. Lb/min	Pounds per minute.
	22. Lb/hr	Pounds per hour.
	(default = 1)	

4.2.5	Model: CONTROLLER / METER
Temperature Unit selection	1. Kelvin 2. Celsius 3. Fahrenheit 4. Rankine *(default = 2)*

4.2.6	Model: CONTROLLER / METER
Totalizer Unit selection (Selection of the unit in which the Totalizer counter is expressed)	1. ml Milliliter. 2. l Liter. 3. m3 Cubic meter. 4. ft3 Cubic feet. 5. g Grams. 6. kg Kilograms. 7. Lb Pounds. *(default = 2)*

4.2.7	Model: CONTROLLER only
Setpoint Source selection (Selection of the input source and range of the setpoint signal.)	1. 0-5 Vdc/0-20 mA 2. 1-5 Vdc/4-20 mA 3. Profibus *(default = 3)*

4.2.8	Model: CONTROLLER only
Softstart Option selection	1. Off 2. Non-linear. 3. Linear up only. 4. Linear down only. 5. Linear (up & down). *(default = 1)*

4.2.9	Model: CONTROLLER only
Adaptive Control selection (Selection of the automatic adaptive valve controller.)	1. Adaptive control off. 2. Tune valve offset. 3. Tune valve offset & span. *(default = 2)*

4.3 MEMORY MAP (BIMF5800.GSD, MODULE "BASIC")

This memory map is for all controller models.

INPUT

Byte 1	Byte 2	Byte 3	Byte 4
Octet Sign, Exponent,	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Flow (see Table 4.2.4 for unit expression) floating point (IEEE 754)			

Byte 5	Byte 6	Byte 7	Byte 8
Octet Sign, Exponent,	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Temperature (see Table 4.2.5 for unit expression) floating point (IEEE 754)			

Byte 9	Byte 10	Byte 11	Byte 12
Octet Sign, Exponent	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Totalizer (see Table 4.2.6 for unit expression) floating point (IEEE 754)			

OUTPUT

Byte 1	Byte 2	Byte 3	Byte 4
Octet Sign, Exponent,	*Octet* Exponent, Mantissa	*Octet* Mantissa	*Octet* Mantissa
Setpoint (see Table 4.2.4 for unit expression) floating point (IEEE 754)			

4.4 MEMORY MAP (BIMF5800.GSD, MODULE "EXTENDED")

This memory map is for all controller models. In this module the command output byte is added against module "Basic".

INPUT

Byte 1	Byte 2	Byte 3	Byte 4
Octet Sign, Exponent	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Flow (see Table 4.2.4 for unit expression) floating point (IEEE 754)			

Byte 5	Byte 6	Byte 7	Byte 8
Octet Sign, Exponent	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Temperature (see Table 4.2.5 for unit expression) floating point (IEEE 754)			

Byte 9	Byte 10	Byte 11	Byte 12
Octet Sign, Exponent	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Totalizer (see Table 4.2.6 for unit expression) floating point (IEEE 754)			

OUTPUT

Byte 1	
High Nibble	Low Nibble
Totalizer command 0 = STOP Totalizer 1 = RUN Totalizer 2 = RESET Totalizer 3…15 = Not Allowed	Valve Override command (controller models only) 0 = Valve override OFF 1 = Valve override OPEN 2 = Valve override CLOSE 3 = Valve override MINIMUM 4 = Valve override MAXIMUM 5 = Valve override FIXED 6…15 = Not Allowed

Byte 2	Byte 3	Byte 4	Byte 5
Octet Sign, Exponent,	*Octet* Exponent Mantissa	*Octet* Mantissa	*Octet* Mantissa
Setpoint (see Table 4.2.4 for unit expression) floating point (IEEE 754)			

4.5 MEMORY MAP (BIMF5860.GSD)

This memory map is for all meter models. In the “Extended” module the command output byte is added versus the “Basic” module.

INPUT

Byte 1	Byte 2	Byte 3	Byte 4
Octet Sign, Exponent,	*Octet* Exponent, Mantissa	*Octet* Mantissa	*Octet* Mantissa
Flow (see Table 4.2.4 for unit expression) floating point (IEEE 754)			

Byte 5	Byte 6	Byte 7	Byte 8
Octet Sign, Exponent,	*Octet* Exponent, Mantissa	*Octet* Mantissa	*Octet* Mantissa
Temperature (see Table 4.2.5 for unit expression) floating point (IEEE 754)			

Byte 9	Byte 10	Byte 11	Byte 12
Octet Sign, Exponent,	*Octet* Exponent, Mantissa	*Octet* Mantissa	*Octet* Mantissa
Totalizer (see Table 4.2.6 for unit expression) floating point (IEEE 754)			

OUTPUT

Byte 1 ***(Module “Extended” only)***	
High Nibble	Low Nibble
Totalizer command 0 = STOP Totalizer 1 = RUN Totalizer 2 = RESET Totalizer 3…15 = Not Allowed	Valve Override command (must be set to 0 for meter models) 1...15 = Not Allowed

Note: Output byte 1 is only valid for module “Extended”. For module “Basic” there are no output bytes!

5 Diagnostic

5.1 DEVICE DIAGNOSTIC MESSAGE

Any Smart TMF series device features extensive diagnostics capabilities. Access to this information is provided through the Profibus-DP defined diagnostics message (i.e. SAP 60). In the start-up state, when connected to the network and prior to entering the data exchange state, the device will generate two diagnostic messages: one right after power up to notify the master of its presence on the network, and one after successful configuration check, to notify the master that the system is ready for regular data exchange.

A device diagnostics message send by a Smart TMF series device will at least contain the 6 bytes of mandatory diagnostics as defined by the standard. Refer to EN 50170, part 3, Section 8.3.1.: *Read DP-slave diagnostic information* for a detailed description of these first 6 bytes. If the device has no error or alarm to report, no further extended diagnostic bytes are send to the master. The mere absence of extended diagnostics information indicates “No errors to report”, thus limiting the burden on the network to a minimum.

Three categories of errors exist:

1. **Run-time message errors**: indicating that an invalid selection code has been send to the device with one of the command bytes. The command has been ignored.
2. **Fatal system errors**: System errors which prevent the device from correct operation. These errors are non-maskable (i.e. they can not be disabled). Occurrence of a fatal error will result in system shutdown.
3. **Non-fatal system errors/alarms**: These errors indicate a situation, which is not fatal and which in due time may disappear or which can not be handled by the device, but which does not prevent operation. These errors are maskable, i.e. they can be disabled through the parameterization message.

A diagnostics message will be send if one of the errors occurs or disappears. A run-time error will be reset after sending the diagnostics message. In the case of non-fatal errors the static-bit is set in the header of the diagnostics message. The message will be continuously re-send to the master, and clog up the network. Immediate action is required. Non-fatal errors are send if one or more of the errors change, i.e. if one error occurs, the diagnostics message is send once, if another occurs, a new message is send, and if the first one disappears, yet another message is send.

In case if one of the errors occurs (or changes), a complete diagnostics message, including also the bytes indicating the other categories will send to the master after the next data exchange message.

Table 5-1 below summarizes the diagnostic data bytes to be send at the event of an error(change). If all bits in all bytes are 0, these data bytes will not be send. A short message indicates “no errors”. The data bytes are send left to right, i.e. byte 0 is send first.

Table 5-1: Diagnostics Message, Extended Data Section Layout.

Diagnostics message – Extended data section*				
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
Run-time message errors	Fatal system errors	Primary non-fatal system errors	Secondary non-fatal system errors	Non-fatal ambient errors

* These bytes are only send if one of the bits is set to 1.

Each of the error/alarm bytes is explained in the next sections.

5.2 RUN-TIME MESSAGE ERRORS

Table 5-2 below shows the bit-mapped alarm bits of the first extended diagnostics byte, the Run-time message errors (Bit 7 is the most significant bit, bit 0 is the least significant bit). These error bits are used to notify the master, that one (or more) of the command settings, send with either the first or the second command byte has been ignored for some reason. The errors are non-fatal, i.e. the device will continue to function as before, but the command involved is ignored. Refer also to section A.4 for an explanation of the valid command byte selection codes.

Table 5-2: Diagnostics: Run-Time Message Error Bits.

Diagnostics byte 0: Run-time message errors							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1*	Bit 0
Reserved				Device busy, command ignored	Invalid totalizer command	Invalid VOR command	Invalid EEPROM command
0	0	0	0	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm

* This error will also be set if the slave device is a meter model, and a non-zero valve override command is given.

Explanation of error bits:

1. **Invalid EEPROM command**: The code send to the slave device with command byte 1 is invalid. i.e. the two least significant bits of the first command byte have both been set to 1.
2. **Invalid VOR command**: The valve override command code send to the slave device with command byte 2 is invalid. Either a number ranging from 6 to 15 has been set in the lower nibble, which is not allowed for a Smart TMF controller model, or a non-zero number has been set and the addressed device is a Smart TMF meter model. The command has been ignored.
3. **Invalid totalizer command**: The totalizer command code send to the slave device with command byte 2 is invalid, i.e. a number ranging from 3 to 15 has been set in the higher nibble. The command has been ignored.
4. **Device busy, command ignored**: Either a zero command code or an EEPROM command code has been send to the device, which is however still processing the previous zero or EEPROM command. The command has been ignored.

5.3 FATAL SYSTEM ERRORS

Table 5-3 below shows the bit-mapped alarm bits of the second extended diagnostics byte, the fatal system errors (Bit 7 is the most significant bit, bit 0 is the least significant bit). These error bits all indicate a fatal system alarm, prevent the device from correct operation. The occurrence of one of these fatal alarms will cause a system shutdown. Also in the diagnostics message the static diagnostics bit will be set, i.e. the diagnostics message is the only message to be send by the device. These alarm situations will not disappear by them selves and immediate service is required.

*Table 5-3: Diagnostics: Fatal System Error Bits***.**

Diagnostics byte 1: Fatal system errors							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved			Sensor zero error	EEPROM error	Database error	SRAM R/W error	EPROM error
0	0	0	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm

Explanation of error bits:

1. **EPROM error**: At start-up (after system reset or power up) the system EPROM, containing the program is checked by determining the checksum. If a checksum error has been detected, the system is shutdown. If communication is achieved, this bit will be set in the second diagnostics byte. The error can not be masked.
2. **SRAM R/W error**: At start-up (after system reset or power up) the performance of the system SRAM is checked by writing and reading specific test patterns at all locations. If a faulty location has been found, the system is shutdown. If communication is achieved, this bit will be set in the second diagnostics byte. The error can not be masked.
3. **Database error**: At start-up (after system reset or power up) and continuously during operation the parameter database is checked by checking each parameter's checksum. If a mismatch is found between the calculated checksum and the stored checksum at a certain parameter location, the database is considered to have become invalid. Bit 2 will be set in the second diagnostics byte, and the system is shutdown. The error can not be masked.
4. **EEPROM error**: During operation the backup parameter database, located in EEPROM is continuously checked by comparing the contents of each parameter in the operational database (including the checksum) with the contents of the backup database. If a mismatch is found between two parameter values, the backup database is considered to have become invalid. Bit 3 will be set in the second diagnostics byte, and the system is shutdown. The error can not be masked.
5. **Sensor zero error**: If after a sensor zero command the processor has been unable to achieve a residual sensor zero signal of less then 5%, the flow sensor measurement accuracy can no longer be guaranteed. Bit 4 will be set in the second diagnostics byte, and the system is shutdown. The error can not be masked.

5.4 PRIMARY NON-FATAL SYSTEM ERRORS

Table 5-4 below shows the bit-mapped alarm bits of the third extended diagnostics byte, the primary non-fatal system errors (Bit 7 is the most significant bit, bit 0 is the least significant bit). These error bits all indicate a primary (i.e. system hardware related) non-fatal system alarm. At the occurrence of one or more of these alarms the device will continue to operate as best as possible. Erroneous signal levels are limited to operational levels before processing and the alarm will disappear if the situation returns to normal. All of these error/alarm message bits can be disabled through the parameterization message.

Table 5-4: Diagnostics: Primary Non-Fatal System Error/Alarm Bits.

Diagnostics byte 2: Primary non-fatal system errors/alarms							
Bit 7	Bit 6 *	Bit 5	Bit 4	Bit 3 *	Bit 2	Bit 1	Bit 0
Res	Valve out of range	Analogue output error	Flow sensor out of range	Setpoint over range	Analogue output out of range	Temp. sensor error	Flow sensor error
0	0	0	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm

* Applies to controller models only. For meter models these bits will never be set.

Explanation of error/alarm bits:

1. **Flow sensor error**: This error occurs if the sensor signal level drops below a minimum level. This may result from a disconnected sensor, but also from reversed flow.
2. **Temperature sensor error**: This error occurs if the sensor signal level drops below a minimum level. This may result from a disconnected sensor.
3. **Analogue output error**: The analogue output error is generated if the analogue output signal level differs more then 10% from the expected level.

It may result from defective electronics.

4. **Setpoint overrange**: The setpoint overrange alarm is set if the setpoint signal, either analogue or through the network exceeds 105%. The setpoint used in processing is limited to 105%.
5. **Flow sensor out of range**: This error occurs if the sensor signal exceeds the maximum physical signal level. The sensor signal level is limited to this maximum before processing.
6. **Analogue output out of range**: This error occurs if the analogue output signal to be set exceeds the maximum physical signal level allowed with the electronics. The analogue output level set is the maximum physical value achievable with the electronics.
7. **Valve out of range**: This error occurs if the control value set on the valve has reached the maximum possible level. The actual value set is limited to the maximum value allowed. This error may result from a situation where there is no gas supplied and yet a setpoint exceeding 0% is present.

5.5 SECONDARY NON-FATAL SYSTEM ERRORS

Table 5-5 below shows the bit-mapped alarm bits of the fourth extended diagnostics byte, the secondary non-fatal system errors (Bit 7 is the most significant bit, bit 0 is the least significant bit). These error bits all indicate a secondary non-fatal system alarm, non-hardware related. At the occurrence of one or more of these alarms the device will continue to operate as best as possible. Again erroneous signal levels are limited to operational levels before processing and the alarm will disappear if the situation returns to normal. All of these error/alarm message bits can be disabled through the parameterization message.

Table 5-5: Diagnostics: Secondary Non-Fatal System Error/Alarm Bits.

Diagnostics byte 3: Secondary non-fatal system errors/alarms							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					Totalizer overflow	High flow error	Low flow error
0	0	0	0	0	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm

Explanation of error/alarm bits:

1. **Low flow error**: This error occurs if the flow signal drops below the low flow alarm limit, set in the database. The alarm will disappear if the signal exceeds the low flow limit again.
2. **High flow error**: This error occurs if the flow signal exceeds the high flow alarm limit, set in the database. The alarm will disappear if the signal drops below the high flow limit again.
3. **Totalizer overflow**: The totalizer overflow error occurs if the maximum value of the totalizer is reached. The totalizer will roll over and start again from 0, but the overflow is signalled to the master. It will only disappear after a totalizer reset.

5.6 NON-FATAL AMBIENT ERRORS

Finally Table 5-6 below shows the bit-mapped alarm bits of the fifth extended diagnostics byte, the non-fatal ambient errors (Bit 7 is the most significant bit, bit 0 is the least significant bit). These error bits all indicate a ambient related non-fatal ambient related alarm. At the occurrence of one or more of these alarms the device will continue to operate as best as possible. Again erroneous signal levels are limited to operational levels before processing and the alarm will disappear if the situation returns to normal. All of these error/alarm message bits can be disabled through the parameterization message.

Table 5-6: Diagnostics: Non-Fatal Ambient Error/Alarm Bits.

Diagnostics byte 4: Non-fatal ambient errors/alarms							
Bit 7	Bit 6	Bit 5 *	Bit 4	Bit 3	Bit 2 *	Bit 1	Bit 0
Reserved		Flow obstruct. error	Temp. too low error	Reserved	No flow indication error	Power too low error	Temp. too high error
0	0	0=OK 1=Alarm	0=OK 1=Alarm	0	0=OK 1=Alarm	0=OK 1=Alarm	0=OK 1=Alarm

* Applies to controller models only. For meter models these bits will never be set.

Explanation of error/alarm bits:

1. **Temperature too high error**: If the ambient temperature exceeds the device's maximum operating temperature, this alarm will be set. It will disappear if the temperature drops below the maximum operating temperature again.
2. **Power too low error**: The power too low error bit is set if the internal analogue power level drops below 12 Vdc. The digital level can still operate, but the analogue read-out can become inaccurate. This may be caused by a short-circuit on board the electronics.
3. **No flow indication error**: This error may occur if the valve out of range alarm is also set. It indicates the absence of flow, although the valve is fully opened. It may be caused by a lack of gas supply. This alarm does not occur if the device is a meter model, and it disappears if the gas flow returns to normal.
4. **Temperature too low error**: If the ambient temperature drops below the device's minimum operating temperature, this alarm will be set. It will disappear if the temperature exceeds the minimum operating temperature again.
5. **Flow obstruction error**: This error may occur if the valve out of range alarm is also set. It indicates a possible obstruction of gas flow, although the valve is fully opened. This may be due to a partially block gas supply or outlet (i.e. the gas is not fully zero). This alarm does not occur if the device is a meter model, and it disappears if the gas flow returns to normal.

Appendix A PROFIBUS-DP Message Services

A.1 INTRODUCTION

This section describes the Profibus-DP Message Services implemented in the Brooks Smart TMF devices. The following message services are supported by any Brooks Smart TMF Series device:

1. Default SAP - Data exchange (Write/Read data)
2. SAP 56 - Read inputs
3. SAP 57 - Read outputs
4. SAP 58 - Global control commands
5. SAP 59 - Read configuration
6. SAP 60 - Read diagnostics information
7. SAP 61 - Set parameters
8. SAP 62 - Check configuration

SAP 55 - Change station address, is not supported, since the Smart TMF Series devices are equipped with address selector switches. The station address is determined by the setting of these switches only. Refer to section 3.5 for address selection. The following sections will describe each supported message service in more detail.

A.2 PARAMETERIZATION MESSAGE

At start up of either the device or the network, the first message to be transferred from the master to the slave will be the parameterization message (SAP 61). This message is used to set the necessary operational and network parameters at the slave. In this start-up state the slave will accept no other messages. Table A-1 below lists the bytes of the parameterization data section. The bytes are send to the device left to right (Byte 0 is send first).

Table A-1: Parameterization Message Data Section Layout.

Parameterization Message - Data Section						
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SPC3 specific	Selected gas number	Analogue output selection	Alarm enable mask 1	Alarm enable mask 2	Alarm enable mask 3	Output enable mask
Byte 7	Byte 8	Byte 9	Byte 10	Byte 11*	Byte 12*	Byte 13*
Input enable mask	Selected Flow Unit	Selected Temp. Unit	Selected totalizer Unit	Selected setpoint source	Selected softstart option	Selected adaptive control option

* These bytes apply to Controller models only. They must not be send when the addressed device is a Meter model.

The data section of the parameterization message consists of at least 11 data bytes. For Smart Mass Flow Controller models 3 more control related selection options are available, adding 3 more bytes to the parameterization message. These bytes must not be send to Smart Mass Flow Meter models, or else the parameterization message will be rejected.

Upon reception of the parameterization message, the device will check the bytes for incorrect settings. If either the amount of data bytes received is incorrect or one of the selected settings is incorrect, the parameterization message will be rejected and the parameter-not-ok message will be returned. The slave will then still await a correct parameterization message, before accepting any other message.

The following sections will discuss the selection options in more detail.

A.2.1 Byte 0 - SPC3 Specific Byte

The first byte, byte 0, is specific to the SPC3 ASIC used to implement the Profibus-DP interface in the Smart Mass Flow Meters and Controllers. This byte is mandatory, all the bits are reserved and should, in the case of the Smart TMF series always be set to 0, see Table A-2 below.

Table A-2: Parameterization byte 0 - SPC3 Specific Syte.

Parameterization Byte 0: SPC3 Specific Byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							
0	0	0	0	0	0	0	0

A.2.2 Byte 1 - Selected Gas Number

The Smart Mass Flow Meters and Controllers allow for storage of up to 10 different gas calibration curves. Each device will be calibrated for the gasses specified by the customer, usually at least one gas. The gas curve to be used when applying the instrument in a process can be set through this parameterization byte, see Table A-3.

Table A-3: Gas Number Selection Codes.

Parameterization Byte 1: Gas Number Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Gas Selection Code							
1 = Gas calibration curve #1 2 = Gas calibration curve #2 3 = Gas calibration curve #3 4 = Gas calibration curve #4 5 = Gas calibration curve #5				6 = Gas calibration curve #6 7 = Gas calibration curve #7 8 = Gas calibration curve #8 9 = Gas calibration curve #9 10 = Gas calibration curve #10 0 = Not allowed 11…255 = Not allowed			

Upon reception of the message this byte is checked for the correct value. Any other number (i.e. 0 or a number ranging from 11 through 255) is considered incorrect and the parameterization message will be rejected. The device does not check whether there is an actual calibration curve at the selected gas number. In that case the default curve is stored at that number and that curve will therefore be used.

A.2.3 Byte 2 - Analogue Output Selection

The analogue output selection byte allows the user to specify the analogue output range or to simply switch it off. The selection affects the voltage output as well as the current output. Table A-4 below lists the valid selection options for the analogue outputs.

Table A-4: Analogue Output Selection Codes.

Parameterization Byte 2: Analogue Output Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Analogue Output Selection Code							
0 = Analogue outputs off 1 = Analogue outputs on, 0 - 5Vdc and 0 - 20 mA 2 = Analogue outputs on, 1 - 5Vdc and 4 - 20 mA 3…255 = Not allowed							

The analogue outputs are calibrated at the factory for one of the ranges. Switching to another range may result in inaccurate output signal reading. Any other selection value will result in the parameterization message being rejected.

A.2.4 Byte 3, 4 and 5 - Alarm Enable Masks

Byte 3, 4 and 5 of the parameterization message are bitmapped enable masks, used to enable or disable specific non-fatal system or ambient alarms. If an alarm is disabled, it is not reported through the diagnostics message, nor will it activate the alarm output. It does not however implicate that the situations, which would generate a certain disabled alarm will not occur.
The following alarm masks can be enabled or disabled (refer to Table A-5, Table A-6, and Table A-7 below):

Table A-5: Primary Non-Fatal System Alarm Masks.

Parameterization byte 3: Enable/Disable Primary Non-Fatal System Alarms							
Bit 7	Bit 6 *	Bit 5	Bit 4	Bit 3 *	Bit 2	Bit 1	Bit 0
Res	Valve out of range	Analogue output out of range	Flow sensor out of range	Setpoint over range	Analogue output error	Temp. sensor error	Flow sensor error
0	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable

* Applies to controller models only. For meter models these bits must be set to 0.

Table A-6: Secondary Non-Fatal System Alarms.

Parameterization byte 4: Enable/Disable Secondary Non-Fatal System Alarms							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					Totalizer overflow	High flow limit	Low flow limit
0	0	0	0	0	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable

Table A-7: Non-Fatal Ambient Alarms.

Parameterization byte 5: Enable/Disable Non-Fatal Ambient Alarms							
Bit 7	Bit 6	Bit 5 *	Bit 4	Bit 3	Bit 2 *	Bit 1	Bit 0
Reserved		Flow obstruction	Temp. too low	Reserved	No flow indication	Power supply too low	Temp. too high
0	0	0=Disable 1=Enable	0=Disable 1=Enable	0	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable

* Applies to controller models only. For meter models these bits must be set to 0.

Bit 7 is the most significant bit, bit 0 is the least significant bit.
Enabling an alarm is done by setting the associated bit to 1, whereas disabling the alarm is done by setting the associated bit to 0. The three non-fatal alarm bytes in the diagnostics message (refer to section 5.1) correspond to the enable/disable masks in byte 3, 4 and 5 of the parameterization message. Each alarm bit flag in the diagnostics message has the same location in the corresponding enable/disable masks byte in the parameterization message. The other alarms in the diagnostics message, the run-time message errors and the fatal system errors can not be disabled. They are always enabled.

The device does not check the enable/disable flags. Enabled bits, associated with non-existing alarms will never result in an alarm message. Enabled bits associated with alarms, which do not apply to the device (e.g. a setpoint over range alarm for a meter model) will also never result in an alarm message.

A.2.5 Byte 6 - Output Enable Mask

Byte 6 of the parameterization message allows the user to select, which of the actual values are to be send from the master to a Smart Mass Flow Meter/ Controller during data exchange. Each individual parameter can be enabled or disabled by setting or clearing the associated bit mask. A disabled parameter will be skipped in the data exchange request messages. This concept allows for user to select a minimum configuration of data to be exchanged between the master and the slave in order to preserve memory space at the master station. On the other hand if memory preservation is not required, a maximum configuration may very well be selected.
The possible selection option are shown in Table A-8 for Controller models and Table A-9 for Meter models:

Table A-8: Output enable mask: Smart Mass Flow Controllers.

Parameterization Byte 6: Output Enable Mask - Smart Mass Flow Controllers							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					Setpoint	Cmd byte 2	Cmd byte 1
0	0	0	0	0	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable

Table A-9: Output Enable Mask: Smart Mass Flow Meters.

Parameterization Byte 6: Output Enable Mask - Smart Mass Flow Meters							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved						Cmd byte 2	Cmd byte 1
0	0	0	0	0	0	0=Disable 1=Enable	0=Disable 1=Enable

Enabling a parameter is done by setting the associated bit to 1, whereas disabling the parameter is done by setting the associated bit to 0. Reserved bits must be set to 0.
Enabling or disabling specified parameters as a part of the data exchange request message will also have its effect on the input/output configuration, to be send to the device for confirmation by the master after the parameterization message has been approved and processed by the device. Refer to Section A.3 for information on the configuration. If any one of the other, non-used bits are enabled, the parameterization message will be rejected. For a Smart Mass Flow Meter device, the setpoint enable bit is considered a non-existing bit. Setting this for a meter model will therefore also result in message rejection. For more information on the actual parameters, refer to Section A.4.

A.2.6 Byte 7 - Input Enable Mask

Byte 7 of the parameterization message allows the user to select, which of the actual parameters are to be send from a Smart Mass Flow Meter/Controller slave device to the master in a response to a data exchange request from the master. This bit mask has the same function as the output enable mask, only it refers to the data exchange response message. Each individual parameter can be enabled or disabled by setting or clearing the associated bit mask. A disabled or non-defined parameter will be skipped in the data exchange response messages.
The possible selection option are shown in Table A-10 for Controller models in Table A-11 for Meter models:

Table A-10: Input Enable Mask: Smart Mass Flow Controllers.

Parameterization Byte 7: Input Enable Mask - Smart Mass Flow Controllers							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Res	Valve	Totalizer	Temp.	Flow	Setpoint	Cmd byte 2 status	Cmd byte 1 status
0	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable

Table A-11: Input Enable Mask: Smart Mass Flow Meters.

Parameterization Byte 7: Input Enable Mask - Smart Mass Flow Meters							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved			Totalizer	Temp.	Flow	Cmd byte 2 status	Cmd byte 1 status
0	0	0	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable	0=Disable 1=Enable

Enabling a parameter is done by setting the associated bit to 1, whereas disabling the parameter is done by setting the associated bit to 0. Reserved bits must always be set to 0. If any one of the other, non-used bits are enabled, the parameterization message will be rejected.

Enabling or disabling specified parameters as a part of the data exchange response message will also have its effect on the input/output configuration, to be send to the device for confirmation by the master after the parameterization message has been approved and processed by the device. Refer to Section A.3 for information on the configuration. For more information on the actual parameters, refer to Section A.4.

A.2.7 Byte 8 - Flow Unit Selection

Through this parameter the user can set the unit to be used in the data exchange of flow values. The unit selected will apply to the actual flow value, but also in the case of Smart Mass Flow Controllers to the setpoint entered through the network. The device itself will convert the value entered.
Either percent of full scale, volumetric flow or mass flow units can be selected. In the conversion of (internal) volumetric flow units to selected volumetric flow units, the flow reference temperature and pressure values, specified at calibration of the selected gas curve are used. For the conversion of (internal) volumetric flow units to mass flow units, the device will use the gas density value as stored with the selected gas calibration curve. Table A-12 below lists the flow unit selection codes.

Table A-12: Flow Unit Selection Codes.

Parameterization Byte 8: Flow Unit Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Flow unit selection code							
Volumetric flow units: 0 = Percent of full scale [%] 1 = Milliliter per second [ml/sec] 2 = Milliliter per minute [ml/min] 3 = Milliliter per hour [ml/hr] 4 = Liter per second [l/sec] 5 = Liter per minute [l/min] 6 = Liter per hour [l/hr] 7 = Cubic meter per second [m^3/sec] 8 = Cubic meter per minute [m^3/min] 9 = Cubic meter per hour [m^3/hr] 10 = Cubic feet per second [ft^3/sec] 11 = Cubic feet per minute [ft^3/min] 12 = Cubic feet per hour [ft^3/hr] 13...15 = Not allowed				Mass flow units: 16 = Grams per second [g/sec] 17 = Grams per minute [g/min] 18 = Grams per hour [g/hr] 19 = Kilograms per second [kg/sec] 20 = Kilograms per minute [kg/min] 21 = Kilograms per hour [kg/hr] 22 = Pounds per second [Lb/sec] 23 = Pounds per minute [Lb/min] 24 = Pounds per hour [Lb/hr] 25 .. 254 = Not allowed 255 = Unspecified (i.e. internal unit = [l/min])			

If the selection is set to 255, i.e. “unspecified”, the internally used flow value, liter per minute or [l/min] will be used. Any other selection value entered for this parameter through the parameterization message will result in the parameterization message being rejected.

A.2.8 Byte 9 - Temperature Unit Selection

Through this parameter the user can select the temperature unit to be used in the data exchange message. The device will present the temperature value in the data exchange response message expressed in the selected unit. The unit selected applies to the actual temperature as measured by the temperature sensor in the device. Table A-13 below lists the temperature unit selection codes.

Table A-13: Temperature Unit Selection Codes.

Parameterization Byte 9: Temperature Unit Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Temperature unit selection code							
Temperature units: 0 = Kelvin [K] 1 = Degrees Celsius [^{O}C] 2 = Degrees Fahrenheit [^{O}F] 3 = Degrees Rankine [^{O}R] 4…254 = Not allowed 255 = Unspecified (i.e. internal unit = Kelvin)							

If the selection is set to 255, i.e. “unspecified”, the internally used temperature value, expressed in Kelvin or [K] will be used. Any other selection value entered for this parameter will result in the parameterization message being rejected.

A.2.9 Byte 10 - Totalizer Unit Selection

Through this parameter the user can select the totalizer unit to be used in the data exchange message. The device will present the totalizer value in the data exchange response message expressed in the selected unit. Either volumetric units or mass units can be selected. In the conversion of (internal) volumetric units to selected volumetric units, the flow reference temperature and pressure values specified at calibration of the selected gas curve, are used. For the conversion of (internal) volumetric units to mass units, the device will use the gas density value as stored with the selected gas calibration curve. Table A-14 below lists the totalizer selection codes.

Table A-14: Totalizer Unit Selection Codes.

Parameterization Byte 10: Totalizer Unit Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Totalizer Unit Selection Code							
Volumetric totalizer units: 0 = Milliliter [ml] 1 = Liter [l] 2 = Cubic meter [m^3] 3 = Cubic feet [ft^3] 4…15 = Not allowed				Mass totalizer units: 16 = Grams [g] 17 = Kilograms [kg] 18 = Pounds [Lb] 19…254 = Not allowed 255 = Unspecified (i.e. internal unit = [l])			

If the selection is set to 255, i.e. “unspecified”, the internally used totalizer value, expressed in Liter or [l] will be used. Any other selection value entered for this parameter through the parameterization message will result in the parameterization message being rejected.

A.2.10 Byte 11 - Setpoint Source Selection

This selection applies to Smart Mass Flow Controllers only. Through this parameter the user can select the source of the setpoint to be used for the control. This source can either be analogue, i.e. through the main connector pin 7 or 8 (Refer to Table 3-1) or digital, i.e. through the network as part of the data exchange message. In the case on an analogue setpoint, selection between voltage or current input is made by setting an internal jumper, refer to the *Installation and Operating Manual Smart TMF series.* Range selection can be made through this parameter. Table A-15 below lists the valid selection options for the setpoint source.

Table A-15: Setpoint Source Selection Codes.

Parameterization Byte 11: Setpoint Source Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Setpoint Source Selection Code							
0 = Not allowed 1 = Analogue setpoint, 0 - 5Vdc or 0 - 20 mA 2 = Analogue setpoint, 1 - 5Vdc or 4 - 20 mA 3 = Digital, through network 4…255 = Not allowed							

The analogue inputs are calibrated at the factory for one of the ranges. Switching to another range may result in inaccurate input signal reading.

Any other selection value entered for this parameter will result in the parameterization message being rejected. Also if the setpoint source selection has been set to digital setpoint (code 3), but the setpoint has not been specified as an output parameter in the output enable mask (refer to Section A.3.13) or vice versa, the parameterization message will be rejected.

A.2.11 Byte 12 - Softstart Selection

This selection applies to Smart Mass Flow Controllers only. Through this parameter the user can select the type of softstart, to be used for the control. This option can be used if rapid changes to the flow, due to setpoint changes are not allowed because of process requirements. Table A-16 below lists the softstart selection codes.

Table A-16: Softstart Selection Codes.

Parameterization Byte 12: Softstart Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Softstart Selection Code							
0 = Off (i.e. No softstart) 1 = Non-linear (classic softstart) 2 = Linear up only 3 = Linear down only 4 = Linear up and down 5…255 = Not allowed							

For fast control, the softstart should be set to off. If one of the linear ramp values has been selected, the softstart ramp value stored in the database is used. The non-linear softstart uses a fixed time constant of 2.5 seconds. Any other selection value entered for this parameter will result in the parameterization message being rejected.

A.2.12 Byte 13 - Adaptive Control Selection

This selection applies to Smart Mass Flow Controllers only. Through this parameter the user can select the type of adaptive control, to be used for the control. When this option is not switched off, the control parameters are constantly adjusted to ensure fast control response under changing process conditions. Table A-17 below lists the adaptive control selection codes.

Table A-17: Adaptive Control Selection Codes.

Parameterization Byte 13: Adaptive Control Selection							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Adaptive Control Selection Code							
0 = Off (i.e. No adaptive control) 1 = Tune valve offset only 2 = Tune valve offset and span 3…255 = Not allowed							

By default the adaptive control option is set to “Tune valve offset” at calibration. It is recommended to leave this option on and not to switch to another option. Any other selection value entered for this parameter will result in the parameterization message being rejected.

A.3 CHECK CONFIGURATION MESSAGES

The device configuration defines the total amount of data bytes, send to a Smart Mass Flow Meter or Controller in a data exchange request message and the total amount of bytes returned by the device in the data exchange response message. After successful parameterization the master device must issue a Check-Configuration message (SAP 62) to the slave, sending with it the presumed configuration. The slave device must check the configuration provided by the device against its own configuration information. If the configurations are the same the device will approve it and data exchange can start. If there is a mismatch, the configuration will be rejected and a parameterization message must be (re-)send.

The configuration for a Smart TMF device depends on the bits enabled in the input definition byte and the output definition byte. In both cases enabling a command byte (status) will contribute 1 byte of information on either the data exchange request or the data exchange response message or both. Any of the other parameters will contribute 2 words each (4 bytes) when enabled.

When receiving the configuration information a Smart TMF series device will determine from the data the amount of output bytes and words, and the amount of input bytes and words as determined by the master . The sequence of the configuration information is not important, since it does not define the sequence of the output and input parameters but rather the amount of bytes to be exchanged.

For a Check Configuration message the configuration data is build up according to the standard using the standard identifier byte format (Refer to EN 50170, part 3, section 8.3.5.: *Check Configuration Data*). Bytes and words can be grouped together using this format, but that is not required. However in all cases the consistency bit flag must be set. Each of the command bytes (or status) will fit in a byte identifier group. The Flow, Setpoint, Temperature and Totalizer parameters are Real (floating point) parameters, which fit in 4 bytes or 2 words. These parameters are identified by word identifiers in the configuration. The Valve control value parameter will be a long unsigned integers, which requires 4 bytes or 2 words. This parameter is also identified by word identifiers in the configuration.

If either one of the consistency bits is not set or the amount of input or output bytes and/or words in a Check Configuration message does not match the internal configuration data of a Smart TMF series device, the configuration will be rejected.

Example:

Parameterization data byte 6: Output enable mask: 0x06, i.e. data exchange request message will contain:
- Command byte 2 (= Bit 1 enabled)
- Setpoint (= Bit 2 enabled)

Parameterization data byte 7: Input enable mask: 0x38, i.e. Data exchange response message will contain:
- Flow (= Bit 3 enabled)
- Temperature (=Bit 4 enabled)
- Totalizer (=Bit 5 enabled)

A.4 DATA EXCHANGE MESSAGES

After successful parameterization and configuration the Smart TMF series device will switch to the data exchange mode, accepting the default SAP message. The data to be exchanged through this SAP has been defined as a part of the parameterization message, i.e. through the bit-mapped output and input definition bytes. The sequence of data is pre-set by the bits: enabled parameters are included, disabled parameters are skipped. The parameters represented by the least significant bit flag are to be placed first in the message, followed by the parameter enabled by the next significant bit and so on.

The first byte, command byte 1 (or status), is a bitmapped byte, through which system commands can be issued. All commands issued through this byte are valid for both Meter and Controller models. Setting one of the bits will start the action related to it, so the bit does not have to be set again in the next data exchange request message.
If bit 0 is set the database currently in RAM will be backed up to non-volatile memory or EEPROM. If bit 1 is set the database currently in RAM will be overwritten with the contents of the database, currently in non-volatile memory. This can be used to discard any changes made and to return to the previous settings. It will only be useful if after changes have been made, the database has not yet been copied to non-volatile memory. If bit 3 is set, a sensor (re)balance or zero command will be issued to the processor. Table A-18 below shows the functions of the first command byte. The status of the action is reflected by the same bits in the command byte 1 status byte in the data exchange response message. If the zero command pushbutton has been pressed, bit 2 will become 1 also.

Table A-18: Command Byte 1 Command Bits.

Data Exchange Message - Command Byte 1							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					ZERO command	EEPROM command	
0	0	0	0	0	0 = Idle 1 = ZERO	00 = Idle 01 = Backup EEPROM 10 = Restore EEPROM 11 = Not Allowed	

The second byte, command byte 2, consists of two nibbles of 4 bits each. Through the lower 4 bits a command can be issued to achieve a valve override, the higher 4 bits can be used to control the totalizer. On a Smart Mass Flow Meter the lower half is not used and should always be set to 0. The contents of the second command byte always reflects the current situation, e.g. as long as the lower nibble is set to code 2, the valve override will be set to CLOSE. When flow control must return to normal, the code must change to 0. The code returned through the command byte 2 status byte in the data exchange response message reflects the current situation of the valve override and the totalizer. Also if a valve override command has been issued through the main connector, it will show up in the lower nibble of the command byte 2 status byte. Table A-19 below shows the command codes.

Table A-19: Command Byte 2 Command Codes.

Data Exchange Message - Command Byte 2							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High nibble = Totalizer command				Low nibble = Valve override command (Controller models only)			
0 = STOP Totalizer 1 = RUN Totalizer 2 = RESET Totalizer				0 = Valve override OFF 1 = Valve override OPEN 2 = Valve override CLOSE 3 = Valve override MINIMUM 4 = Valve override MAXIMUM 5 = Valve override FIXED 6..15 = Not Allowed			

All the following parameters 4 bytes in size and expressed in 2 words. Both flow and setpoint (if applicable to the device) are Real (or floating point) values, expressed in the unit selected through the parameterization message. Both value are exchanged with the most significant byte first. The temperature value as well as the totalizer, value returned through the data exchanged response message (if enabled) are also Real values, expressed in the unit, selected through the parameterization message. Finally the valve value (if enabled) returned with the data exchange response message is a 32 bit unsigned long integer number, expressed as 2 words. This number is also returned with its most significant byte first.

Example:
Slave Device: 5850S Smart Mass Flow Controller.

Table A-20: Example Parameterization Byte 6.

Output Enable Mask in Parameterization Message = 0x07							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					Setpoint	Cmd byte 2	Cmd byte 1
0	0	0	0	0	1	1	0

Table A-21: Example Parameterization Byte 7.

Input Enable Mask in Parameterization Message = 0x1B							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Res	Valve	Totalizer	Temp.	Flow	Setpoint	Cmd byte 2 status	Cmd byte 1 status
0	0	0	0	0	1	1	0

Data exchange response message will contain:

- Command byte 2
- Setpoint

Data exchange request message will contain:

- Flow
- Temperature
- Totalizer

The data exchange request and response messages are show in the tables below

Table A-22: Data Exchange Request Message Example.

Data Exchange Request Message - Data Section				
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Cmd byte 2	Setpoint			

*Table A-23: Data Exchange Response Message Example***.**

Data Exchange Response Message - Data Section											
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11
Flow				Temperature				Totalizer			

A.5 READ INPUTS AND OUTPUT DATA

A master device can at any time get a picture of the current input and output state of a Profibus-DP slave, by reading the slave's input or output data. A Smart Mass Flow Meter or Controller, will return the last processed input data and the last processed output data. Its contents size will be according to the input and output definition bytes as set through the parameterization message.

A.6 GLOBAL CONTROL COMMANDS

The Profibus standard provides the possibility to issue global command to one or more (e.g. a pre-defined group of potentially different) slave devices. These commands are pre-defined bit mapped commands in the global command data byte, and both the Smart Mass Flow Meter and Controller models will support two of these commands.

Sending a global command involves the use of the global station address, number 127 as well as the group address, set at parameterization. Both devices will support the fail- safe option as well as the sync/unsync option. Both will not support the freeze/unfreeze option. Refer to EN 50170, part 3, section 8.3.7: *Control commands to DP-slave* for a detailed description of this command and the features.

A.6.1 Fail-safe Option

Both device types will support the fail-safe option. This feature allows a global clearing of output data by a Clear-data command, which may be send by the master to all or to a selected group of devices if a network failure is detected by the master. If bit 1 = Clear-data is set in the global command data byte, the device will enter the fail-safe mode, i.e. it will accept the next data exchange request messages if they have no data bytes. The device behaviour to this must pre-programmed. A device will leave the fail-safe mode if a data exchange request is received with valid data bytes or if a global control command is received with bit 1 in the data byte cleared.

A Smart Mass Flow Meter will simply accept the no-data messages with no special change in behaviour, i.e. it will continue to accept (empty) data exchange requests and it will continue to respond with measurement data. This does not depend on whether any of the parameters in the request message has been enabled or not.

A Smart Mass Flow Controller will, upon reception of the global Clear-data command set the valve override to off, i.e. it will set the valve control value to 0. If a normally closed valve is used, the valve will now close, and no control is possible. If a normally open valve is used, the valve will now fully open. Again no control is possible. The user will have to make sure the right valve for the application is installed. Also, if the setpoint has been enabled as a parameter to be set by the master device through the data exchange request message, the device will itself set the last entered setpoint to 0.0. It will switch back to normal control if a data message with a new setpoint has been received.

A.6.2 Sync/Unsync Option

In addition both device model types will support the sync/unsync option. This feature allows a global, synchronized processing of the latest entered output data.

If bit 5 = Sync is set in the global command data byte, the device will still accept data exchange request message with valid data bytes, but they will not be processed internally. A succeeding message with non-zero contents will overwrite the previous entered data, but the data is still not processed. Upon reception of a global control command with bit 6 = Unsync set, the last entered values will be processed. The sync/unsync cycle applies only to the data bytes entered through the data exchange request message, i.e. disabled parameters are not effected.

For a Smart Mass Flow Meter this command only applies to the first two command bytes (if enabled). The sync/unsync feature allows (e.g.) an application start or stop a number of totalizers at the same time. Also a zero action or a database backup action may be initiated at the same time if the application requires this.

In addition the sync/unsync feature will apply to the setpoint (if enabled, and if entered through the network) in the case of a Smart Mass Flow Controller. If bit 5 = Sync, is set in a global control command message, any subsequent setpoint entered through the network will not be processed. Up on the reception of global control command message with bit 6 = Unsync set, the last entered setpoint will be processed. This allows a gas flow application, involving multiple Mass Flow Controllers to synchronize the flow of gas in a process chamber.

NOTE: The sync/unsync command only applies to the data entered or set through data exchange request message. It does NOT apply to the analogue entered setpoint or valve override command.

Appendix B IEEE 754 Floating Point Format

This format is based on the IEEE 754 single precision floating point standard:

S EEEEEEE	E MMMMMMM	MMMMMMMM	MMMMMMMM
byte #0	byte #1	byte #2	byte #3

Where: S – Sign of mantissa (1 = negative)
E – Exponent; biased by 127 in two's complement format
M – Mantissa; 23 least significant bits, fractional portion
The value of a parameter described in the above format can thus be found by:

$$\text{Value} = S\ 1.M * 2^{(E-127)}$$

Although this format is also used in most personal computers, a procedure is given in order to construct the four bytes from a given floating point value:

a. Preserve the sign.
b. Divide the (absolute) floating point value of times by 2 in order to bring the remaining result to a value between 1.0 and 2.0. Add 127 to the number of divisions. This will be the exponent. Subtract 1.0 from the remainder.
c. The remainder is the mantissa where the most significant bit expresses 2^{-1}, the next bit 2^{-2}, the third bit 2^{-3}, etc.

Example: Express 10.254 in IEEE 754 format

a. Sign bit is 0: positive.
b. Dividing 10.254 3 times by 2 leaves 1.28175. The exponent will be 3 + 127 = 130 or 82 hexadecimal. Shifted on location to the right it becomes 41_h. The least significant bit from 82_h shifts into the most significant bit of the mantissa byte but is zero in this case which has no effect on the mantissa. Subtract 1.0 from the remainder. It leaves 0.28175.
c. $0.28175 = 0*2^{-1} + 1*2^{-2} + 0*2^{-3} + 0*2^{-4} + 1*2^{-5} + 0*2^{-6} + \ldots..$
The mantissa will then be 01001000…. or 48 20 C4 hexadecimal. Shifted one location to the right it becomes : $24\ 10\ 62_h$.
d. The result according to scheme above is: 41 24 10 62

The floating point parameters not used by a device will be filled with 7F A0 00 00 (hexadecimal) or 'Not-A-Number'.

Appendix C: Repair and/or Warranty Request Sheet

WARRANTY

Please reference the back cover of this manual for complete details.

RETURN SHIPMENT

Any assembly or part must be returned with a Return Warranty Request. A copy of the Return Warranty Request is available from all Sales Offices and Factories and one is also enclosed with this manual (see next page). Information describing the problem, corrective action, if any, and the work to be performed at the factory must be included.

Repair and/or Warranty Request Sheet

Originator : Date :
Company :
Customer reference no. : CC. :
Brooks serial no. :
Model/Part no. :
Date of delivery :
Date of installation :
Failure date :
Requested delivery time :

TO: REPAIR DEPARTMENT Thermal Mass Flow Devices
Fax no.: +31 (0)318-549299

FOR: 0 Repair 0 Calibration 0 Exchange 0 Quotation
0 Credit 0 Other 0 Warranty

PROCESS CONDITIONS

Fluid name : Pressure P1 :
Flow range : Pressure P2 :
Temperature : In- and/or output :
Attitude : Ref. Temperature :

INSTRUMENT CONDITIONS

Internals are clean : YES / NO
Solvent to clean internals :

If this is not a standard cleaning solvent, the instrument will be returned for cleaning.

Be precise with this info for the safety of goods-receiving staff and technicians.
We cannot accept repair orders without proper information.

REPAIR ACTIVITY INSTRUCTIONS

SHIPPING ADDRESS

METHOD OF SHIPPING

PLEASE FILL IN THIS SHEET COMPLETELY TO AVOID MISTAKES

6 Modellisting

BROOKS SMART MASS FLOW PRODUCTS SMART MASS FLOW METERS / CONTROLLERS	
BASE MODEL NUMBER	**DESCRIPTION**
5860S/BA	MASS FLOW METER; F.S. FLOW RANGES: 0.003 - 0.008 ln/min.
5860S/BC	MASS FLOW METER; F.S. FLOW RANGES: 0.008 - 30 ln/min.
5861S/BD	MASS FLOW METER; F.S. FLOW RANGES: 20 - 100 ln/min.
5863S/BE	MASS FLOW METER; F.S. FLOW RANGES: 100 - 200 ln/min.
5863S/BF	MASS FLOW METER; F.S. FLOW RANGES: 200 - 300 ln/min.
5863S/BG	MASS FLOW METER; F.S. FLOW RANGES: 300 - 400 ln/min.
5863S/BH	MASS FLOW METER; F.S. FLOW RANGES: 400 - 500 ln/min.
5863S/BJ	MASS FLOW METER; F.S. FLOW RANGES: 500 - 600 ln/min.
5863S/BK	MASS FLOW METER; F.S. FLOW RANGES: 600 - 700 ln/min.
5863S/BL	MASS FLOW METER; F.S. FLOW RANGES: 700 - 800 ln/min.
5863S/BM	MASS FLOW METER; F.S. FLOW RANGES: 800 - 900 ln/min.
5863S/BN	MASS FLOW METER; F.S. FLOW RANGES: 900 - 1000 ln/min.
5864S/BO	MASS FLOW METER; F.S. FLOW RANGES: 18 - 80 m3n/h. (1,5")
5864S/BP	MASS FLOW METER; F.S. FLOW RANGES: 60 - 140 m3n/h. (2")
5864S/BR	MASS FLOW METER; F.S. FLOW RANGES: 140 - 320 m3n/h. (3")
5864S/BS	MASS FLOW METER; F.S. FLOW RANGES: 240 - 540 m3n/h. (4")
5864S/BT	MASS FLOW METER; F.S. FLOW RANGES: 540 - 1250 m3n/h. (6")
5864S/BU	MASS FLOW METER; F.S. FLOW RANGES: 970 - 2160 m3n/h. (8")
5850S/BA	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 0.003 - 0.008 ln/min.
5850S/BC	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 0.008 - 30 ln/min.
5851S/BD	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 20 - 100 ln/min.
5853S/BE	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 100 - 200 ln/min.
5853S/BF	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 200 - 300 ln/min.
5853S/BG	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 300 - 400 ln/min.
5853S/BH	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 400 - 500 ln/min.
5853S/BJ	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 500 - 600 ln/min.
5853S/BK	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 600 - 700 ln/min.
5853S/BL	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 700 - 800 ln/min.
5853S/BM	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 800 - 900 ln/min.
5853S/BN	MASS FLOW CONTROLLER; F.S. FLOW RANGES: 900 - 1000 ln/min.
	MECHANICAL CONNECTIONS
1A	WITHOUT ADAPTORS (9/16"-18" UNF) (ONLY FOR 5850/51/53 AND 5860/61/63)
1B	1/4" TUBE COMPRESSION FITTINGS (ONLY FOR 5850/51 AND 5860/61)
1C	1/8" TUBE COMPRESSION FITTINGS (ONLY FOR 5850/60)
1D	3/8" TUBE COMPRESSION FITTINGS (ONLY FOR 5851/61)
1E	1/4" VCR (ONLY FOR 5850/51 AND 5860/61)
1F	1/4" VCO (ONLY FOR 5850/51 AND 5860/5861)
1G	1/4" NPT (ONLY FOR 5850/51 AND 5860/61)
1H	6mm TUBE COMPRESSION FITTINGS (ONLY FOR 5850/51 AND 5851/61)
1J	10mm TUBE COMPRESSION FITTINGS (ONLY FOR 5851/61)
1K	1/4" BSP (F)
1Y	½" BSP (F) (ONLY FOR 5853/63)
1Z	1" BSP (F) (ONLY FOR 5853/63)
2A	1 1/16" - 12SAE/MS (ONLY FOR 5853/63)
2B	½" TUBE COMPRESSION FITTINGS (5853/63 + 5851/61>30 lpm)
2C	3/4" TUBE COMPRESSION FITTINGS (ONLY FOR 5853/63)
2D	1" TUBE COMPRESSION FITTINGS (ONLY FOR 5853/63)
2E	½" NPT(F) (ONLY FOR 5853/63)
2F	1" NPT(F) (ONLY FOR 5853/63)
2G	1½" NPT(F) (SEE OPTION "E") (ONLY FOR 5853/63/64)
2H	½" VCO (100 ln/min. max.) (ONLY FOR 5853/63)
2J	3/4" VCO (ONLY FOR 5853/63)
2K	½" VCR (100 ln/min. max.) (ONLY FOR 5853/63)

BROOKS SMART MASS FLOW PRODUCTS SMART MASS FLOW METERS / CONTROLLERS				
BASE MODEL NUMBER			**DESCRIPTION**	
			MECHANICAL CONNECTIONS	
2L			DIN DN15PN40	(ONLY FOR 5853/63)
2M			DIN DN25PN40	(ONLY FOR 5853/63)
2N			DIN DN40PN40	(ONLY FOR 5853/63)
2O			DIN DN50PN40	(ONLY FOR 5853/63)
2P			ANSI ½" 150 LBS	(ONLY FOR 5853/63)
2R			ANSI ½" 300 LBS	(ONLY FOR 5853/63)
2S			ANSI 1" 150 LBS	(ONLY FOR 5853/63)
2T			ANSI 1" 300 LBS	(ONLY FOR 5853/63)
2U			ANSI 1½" 150 LBS	(ONLY FOR 5853/63)
2V			ANSI 1½" 300 LBS	(ONLY FOR 5853/63)
2W			ANSI 2" 150 LBS	(ONLY FOR 5853/63)
2X			ANSI 2" 300 LBS	(ONLY FOR 5853/63)
3A			2"NPT(F) (SEE OPTION "E")	(5864 ONLY)
3B			ANSI 3" - 150 LBS	(5864 ONLY)
3C			ANSI 3" - 300 LBS	(5864 ONLY)
3D			ANSI 3" - 600 LBS	(5864 ONLY)
3E			DIN DN80 - PN40	(5864 ONLY)
3F			DIN DN80 - PN64	(5864 ONLY)
3G			DIN DN80 - PN100 (MAX. 85 BAR)	(5864 ONLY)
4A			ANSI 4" - 150 LBS	(5864 ONLY)
4B			ANSI 4" - 300 LBS	(5864 ONLY)
4C			ANSI 4" - 600 LBS	(5864 ONLY)
4D			DIN DN100 - PN16	(5864 ONLY)
4E			DIN DN100 - PN40	(5864 ONLY)
4F			DIN DN100 - PN64	(5864 ONLY)
5A			6" ANSI - 150 LBS	(5864 ONLY)
5B			6" ANSI - 300 LBS	(5864 ONLY)
5C			6" ANSI - 600 LBS	(5864 ONLY)
5D			DIN DN 150 - PN 16	(5864 ONLY)
5E			DIN DN 150 - PN 40	(5864 ONLY)
5F			DIN DN 150 - PN 64	(5864 ONLY)
6A			ANSI 8" - 150 LBS	(5864 ONLY)
6B			ANSI 8" - 300 LBS	(5864 ONLY)
6C			DIN DN200 - PN10	(5864 ONLY)
6D			DIN DN200 - PN16	(5864 ONLY)
6E			DIN DN200 - PN25	(5864 ONLY)
6F			DIN DN200 - PN64	(5864 ONLY)
9Z			SPECIFY	
			O-RING/VALVE SEAT MATERIAL	
	A		VITON	
	B		BUNA (NOT FOR 5853)	
	C		PTFE/KALREZ (KALREZ FOR SENSOR 0-RINGS AND VALVE SEAT)	
	D		KALREZ (NOT FOR 5853)	
	E		PTFE O-RINGS / EPDM VALVE SEAT	
	M		KALREZ O-RINGS / METAL VALVE SEAT	
	Z		SPECIFY	
			VALVE TYPE	
		0	METER ONLY (NO VALVE)	
		1	NORMALLY CLOSED (5850/51 SERIES)	
		2	NORMALLY CLOSED (PRESS.DIFF. >2BAR. 5853 SERIES)	
		3	NORMALLY CLOSED (PRESS.DIFF. <2BAR. 5853 SERIES)	
		4	NORMALLY OPENED (5850 ONLY)	
		5	NORMALLY CLOSED, 5850 SERIES, 300 BAR	
		9	SPECIFY	

BROOKS SMART MASS FLOW PRODUCTS SMART MASS FLOW METERS / CONTROLLERS								
BASE MODEL NUMBER								**DESCRIPTION**
								ELECTRICAL INPUT/OUTPUT
								INPUT / **OUTPUT**
	A							0-5Vdc / 0-5 Vdc & 0-20mA (INCL. RS 232, 9600 BDS)
	B							4-20mA / 4-20 mA & 1-5Vdc (INCL. RS 232, 9600 BDS)
	C							0-20 mA / 0-20mA & 0-5Vdc (INCL. RS 232, 9600 BDS)
	D							1-5Vdc / 1-5 Vdc & 4-20mA (INCL. RS 232, 9600 BDS)
	E							DIG. COMM. / DIG. COMM. + 0 - 5 Vdc
	F							DIG. COMM. / DIG. COMM. + 4 - 20 mA
	G							DIG. COMM. / DIG. COMM. + 0 - 20 mA
	H							DIG. COMM. / DIG. COMM. + 1 - 5 Vdc
	I							DIG. COMM. / DIGITAL COMMUNICATION (ONLY)
	Z							SPECIFY
								COMMUNICATION / BAUDRATE
		A 0						ANALOG I/O AND RS 232 & 9600 BAUD
		B*						RS232
		C*						RS485
		D 0						PROFIBUS-DP
		*1						38400 Baud
		*2						19200
		*3						9600
		*4						7200
		*5						4800
		*6						3600
		*7						2400 * BOTH HAVE TO BE SPECIFIED
		*8						1200
								INTERCONNECTION CABLE
			A					NO CABLE
			B					MATING CONNECTOR ONLY
			C					3m ROUND CABLE
			D					6m ROUND CABLE
			E					3m ROUND CABLE INCLUDING COMMUNICATION CABLE
			F					6m ROUND CABLE INCLUDING COMMUNICATION CABLE
			Z					SPECIFY
								ENHANCEMENTS
				A				STANDARD RESPONSE:< 1 SEC (5850/51) < 3 SEC (5853) [1].
				B				FAST RESPONSE (SPECIFY VALUES .... SEC.) [1]
				C				LINEAR RAMP (SPECIFY VALUES ....%/SEC.) [1]
				D				FLOW OUTPUT DAMPING (SPECIFY VALUES .... SEC.) [1]
								CALIBRATION
					0			UNCALIBRATED
					1			STANDARD CALIBRATION INCLUDED
					2			STORAGE OF MULTIPLE CAL. CURVES; ADD PER AVAILABLE CALIBRATION GAS
					9			SPECIFY
								POWER SUPPLY INPUT
						A		± 15 Vdc
						B		+ 24 Vdc = (Standard selection)
						C		+ 15 Vdc only
						Z		SPECIFY
								AREA CLASSIFICATION
							1	SAFE AREA
							2	CERTIFIED FOR USE IN ZONE 2
							9	SPECIFY
5850S/BC 1H A 1 A B3 C A 1 B 1 =								**TYPICAL MODEL NUMBER**

LIMITED WARRANTY

Seller warrants that the Goods manufactured by Seller will be free from defects in materials or workmanship under normal use and service and that the Software will execute the programming instructions provided by Seller until the expiration of the earlier of twelve (12) months from the date of initial installation or eighteen (18) months from the date of shipment by Seller.
Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer.
All replacements or repairs necessitated by inadequate preventive maintenance, or by normal wear and usage, or by fault of Buyer, or by unsuitable power sources or by attack or deterioration under unsuitable environmental conditions, or by abuse, accident, alteration, misuse, improper installation, modification, repair, storage or handling, or any other cause not the fault of Seller are not covered by this limited warranty, and shall be at Buyer's expense.
Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period or ninety (90) days, whichever is longer. This limited warranty is the only warranty made by Seller and can be amended only in a writing signed by an authorized representative of Seller.

BROOKS SERVICE AND SUPPORT

Brooks is committed to assuring all of our customers receive the ideal flow solution for their application, along with outstanding service and support to back it up. We operate first class repair facilities located around the world to provide rapid response and support. Each location utilizes primary standard calibration equipment to ensure accuracy and reliability for repairs and recalibration and is certified by our local Weights and Measures Authorities and traceable to the relevant International Standards.
Visit www.BrooksInstrument.com to locate the service location nearest to you.

START-UP SERVICE AND IN-SITU CALIBRATION

Brooks Instrument can provide start-up service prior to operation when required.
For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.

CUSTOMER SEMINARS AND TRAINING

Brooks Instrument can provide customer seminars and dedicated training to engineers, end users and maintenance persons.

Please contact your nearest sales representative for more details.

HELP DESK

In case you need technical assistance:

Americas	☎ 1 888 554 FLOW
Europe	☎ +31 (0) 318 549 290
Asia	☎ +81 (0) 3 5633 7100

Due to Brooks Instrument's commitment to continuous improvement of our products, all specifications are subject to change without notice.

TRADEMARKS

Brooks ..... Brooks Instrument, LLC
Buna ..... DuPont Dow Elastomers
Kalrez ..... DuPont Dow Elastomers
Teflon ..... E.I. DuPont de Nemours & Co.
Viton ..... DuPont Performance Elastomers

ISO 9001 QUALITY SYSTEM

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